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AFWA Environmental Modeling Overview of Current Capabilities & Operational Needs

**ESPC Workshop
21 Mar 2012**

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Deputy Director***



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Overview



- **AFWA Mission**
- **Operational Needs for Modeling**
- **Current Modeling Capabilities**
 - Clouds (CDFS II)
 - Land surface (LIS)
 - Global NWP (UKMO Model)
 - Regional NWP (WRF)
 - Ensemble modeling (NUOPC and WRF based)
 - Dust/Aerosol (DTA & WRF-chem)
 - Space weather models
- **Extended Range Forecasting**
 - Seasonal to Multi-Decadal
- **HPC Modeling System**



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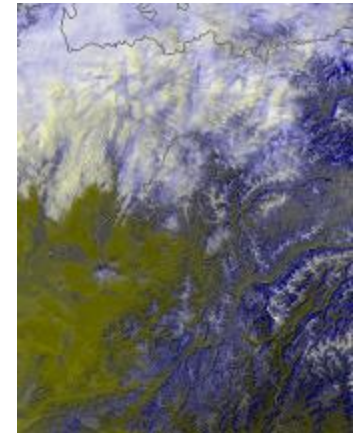
AFWA Mission

A Global Team for the Global Fight



**Maximizing America's
Power through the
Exploitation of Timely,
Accurate, and Relevant
Weather Information;
*Anytime, Everywhere***

Full spectrum characterization of the current and predicted state of the air and space environment for the USAF, US Army, Special Operations Forces, and National Intelligence Community



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Operational Needs For Modeling

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Operational Needs

Source Documents



- **METOC Environment Initial Capabilities Document (ICD)**
- **Air Force Weather Characterization and Model Exploitation Implementation Plan**
- **Functional Area Analysis of the DoD Requirements for Natural Environmental Parameters Collection (NEPC)**
- **Air Force Weather Priorities Plan**
- **COCOM requests for seasonal and inter-annual outlooks to support contingency & logistical planning**
- **OSD inquiries on projected climate change impacts**



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Operational Needs



- **Improved forecasts of global and regional clouds**
 - Cloud coverage, types, heights & bases
 - Cloud optical properties/optical thickness (atmospheric transmissivity)
 - Resolution at 5km or better
- **Improved forecasts of obscurants to visibility**
 - Cloud Free Line of Sight (CFLOS), aka slant path visibility to target
 - Flight-level visibility
 - Dust and smoke concentrations
 - Aerosol optical depth
 - Volcanic Ash



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Operational Needs



- **Exploit ensemble model output for military applications**
 - **Aviation routing (flight plan optimization)**
 - **Aviation hazards (probability-based convection, icing, and turbulence—to include low-level turbulence)**
 - **Weather effects on weapons, warfighters, and adversaries (probability-based decision aids)**
 - **Boundary layer wind variability/uncertainty (NBC dispersion forecasts)**
 - **Resource protection (forecasts for severe weather parameters)**
 - **Ice and snow detection/characterization and runoff (to include snow depth)**



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Operational Needs



- **Integrated/Synchronized data across environmental domains (air, land, space, and ocean)**
 - **Need a coherent, timely, four-dimensional representation to apply METOC information in all environmental domains at all scales**
- **An "analysis of record"**
 - **Comprehensive set of the best possible analyses of the atmosphere at high spatial and temporal resolution with particular attention placed on weather and climate conditions near the surface**



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Operational Needs



- **Improved intensity and track forecasts for tropical storms to support the Joint Typhoon Warning Center and other worldwide forecast centers**
- **Improved forecasts for severe weather parameters**
 - **Resolve sub grid-scale severe weather phenomena to better specify tornados, winds, hail, and lightning**
 - **Convection on-set**



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Current Modeling Capabilities



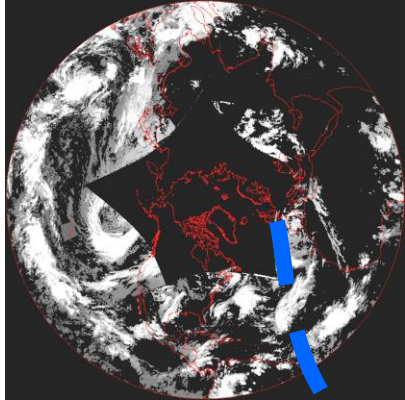
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Global Cloud Analysis Model

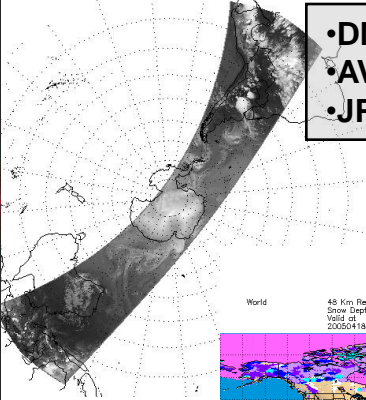
CDFS II



Geostationary Data

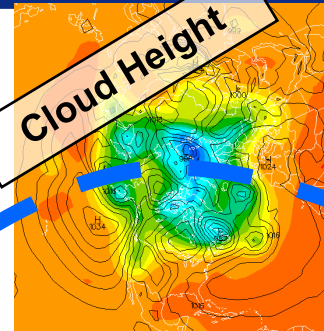


Polar Orbiting Data



- DMSP
- AVHRR
- JPSS (Future)

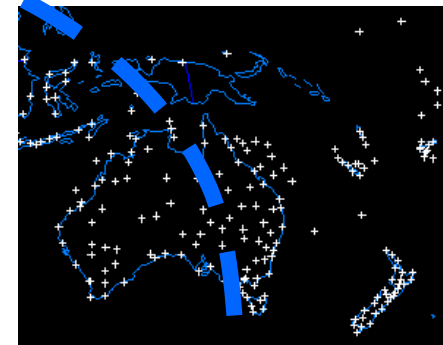
Cloud Height



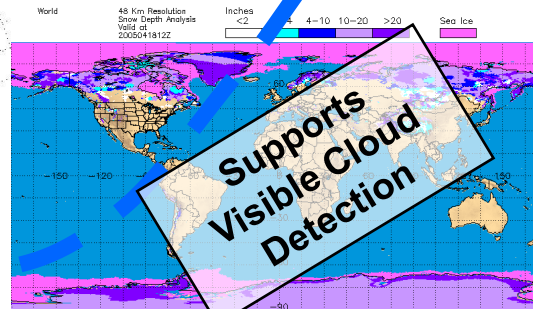
GFS

Upper Atmos. Temp
Near Surface Temp/RH/Wind

Surface Observations



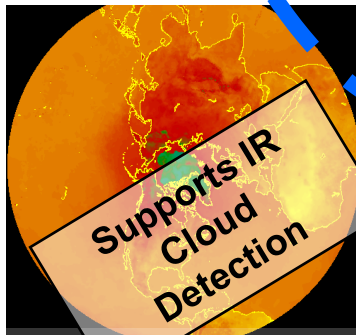
Supports Visible Cloud Detection



Snow Analysis

Resolution: 12 nm
Obs: Surface, SSM/I
Freq: Daily, 12Z

Supports IR Cloud Detection



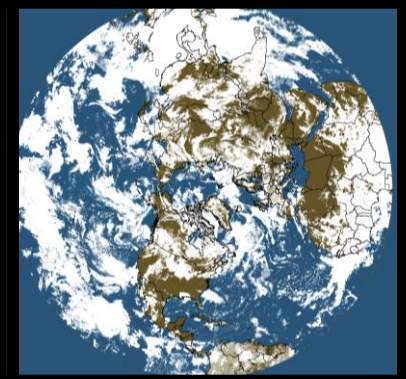
Surface Temp Analysis

Resolution: 12 nm
Obs: IR imagery,
SSM/I Temp
Freq: 3 Hourly

World-Wide Merged Cloud Analysis (WWMCA)

Hourly, global, real-time, cloud analysis @12.5nm

Total Cloud and Layer Cloud data supports National Intelligence Community, cloud forecast models, and global soil temperature and moisture analysis.



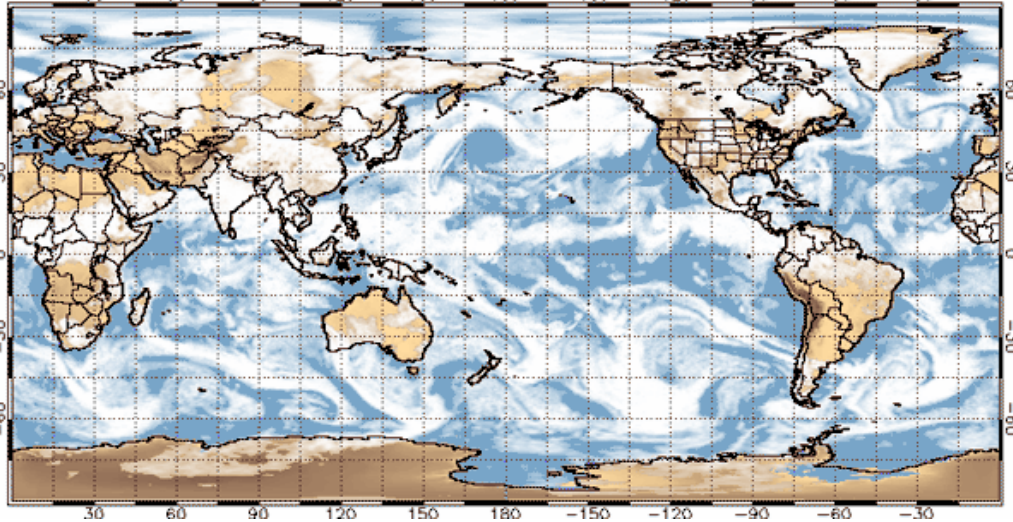


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Cloud Forecast Models

TOTAL CLOUD AMOUNT
GREY SHADES REPRESENT PERCENT COVERED BY CLOUD
06HR FCST VALID 18Z 20 JUL 2006 Mesh: 16 zoom ratio = 1:0.50



Products (global and regional):

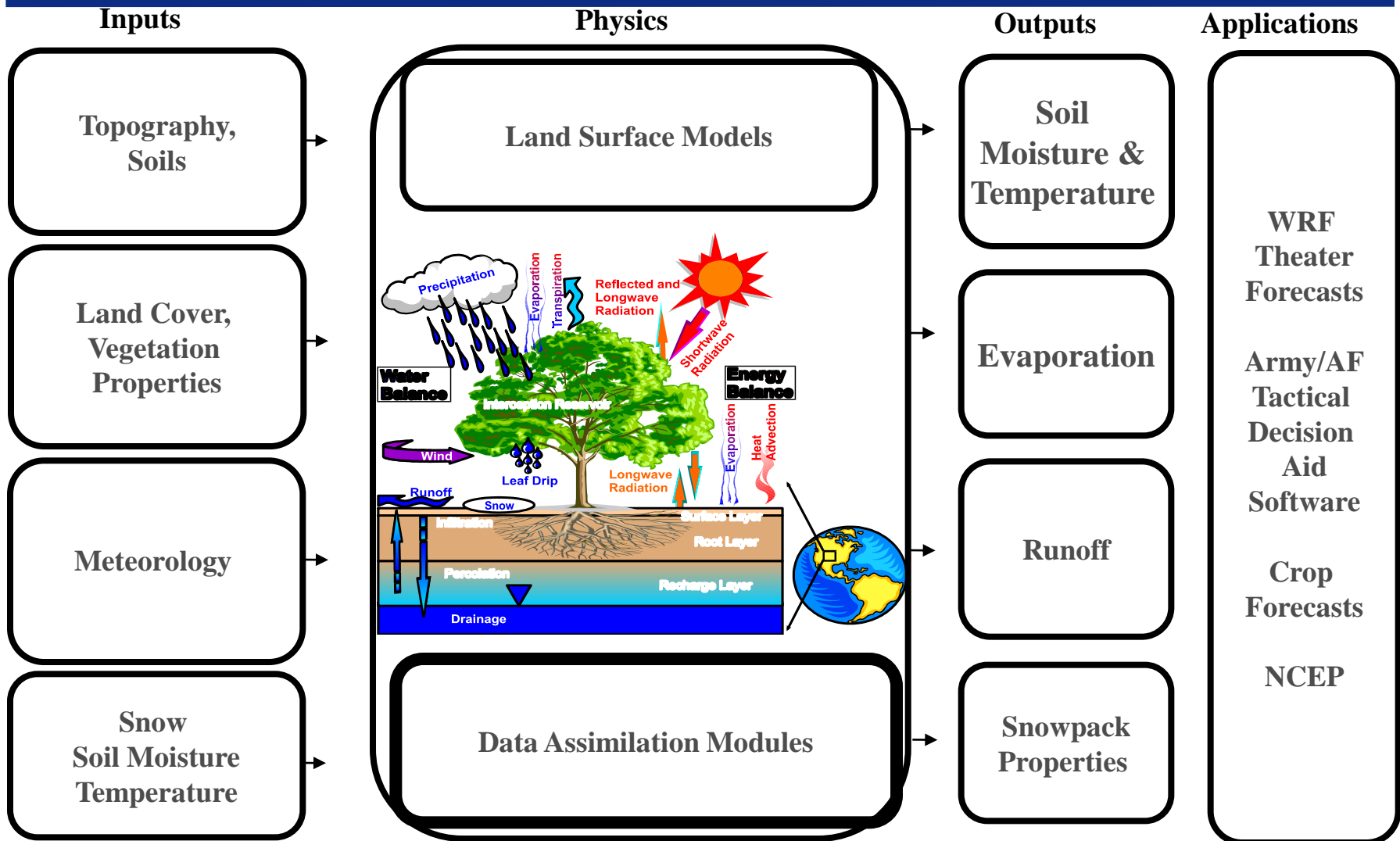
- Total fractional cloud coverage
- Layer coverage (5-layers)
- Layer top height & thickness
- Layer type

- Diagnostic Cloud Forecasts based on statistical paring of WRF & GFS output with CDFS-II WWMCA analysis
- Global forecasts at 25 km resolution
- Regional forecasts at 15 & 5 km resolution
- 3-hr time step
- 30 to 84 hr forecast length (depends on grid)



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Land Surface Modeling LIS



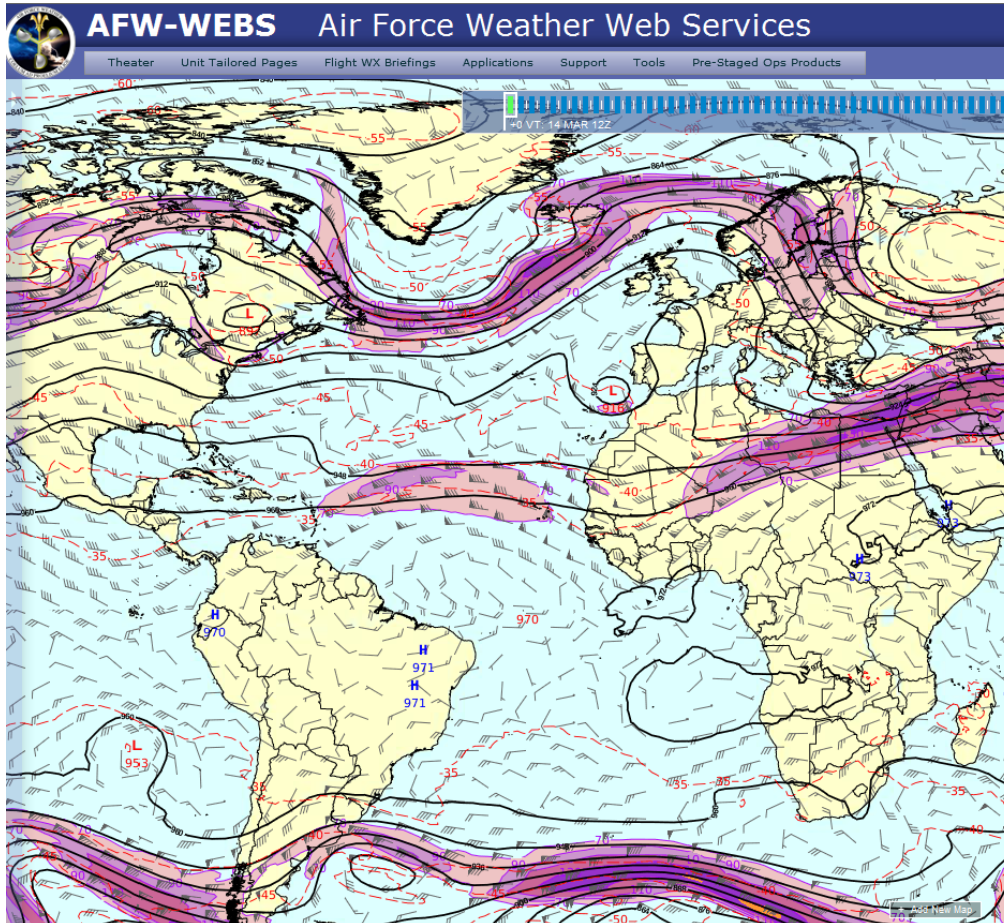
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Global NWP

United Kingdom Met Office Model



UKMO Model at AFWA

- Initialization grids obtained from Exeter
- Model runs 4x/day at 20 km resolution to 240 hours
- Provides initial/lateral boundary conditions for WRF regional runs
- Standard products available via AFW-WEBS
- Gridded data sharing limited to DoD & allies



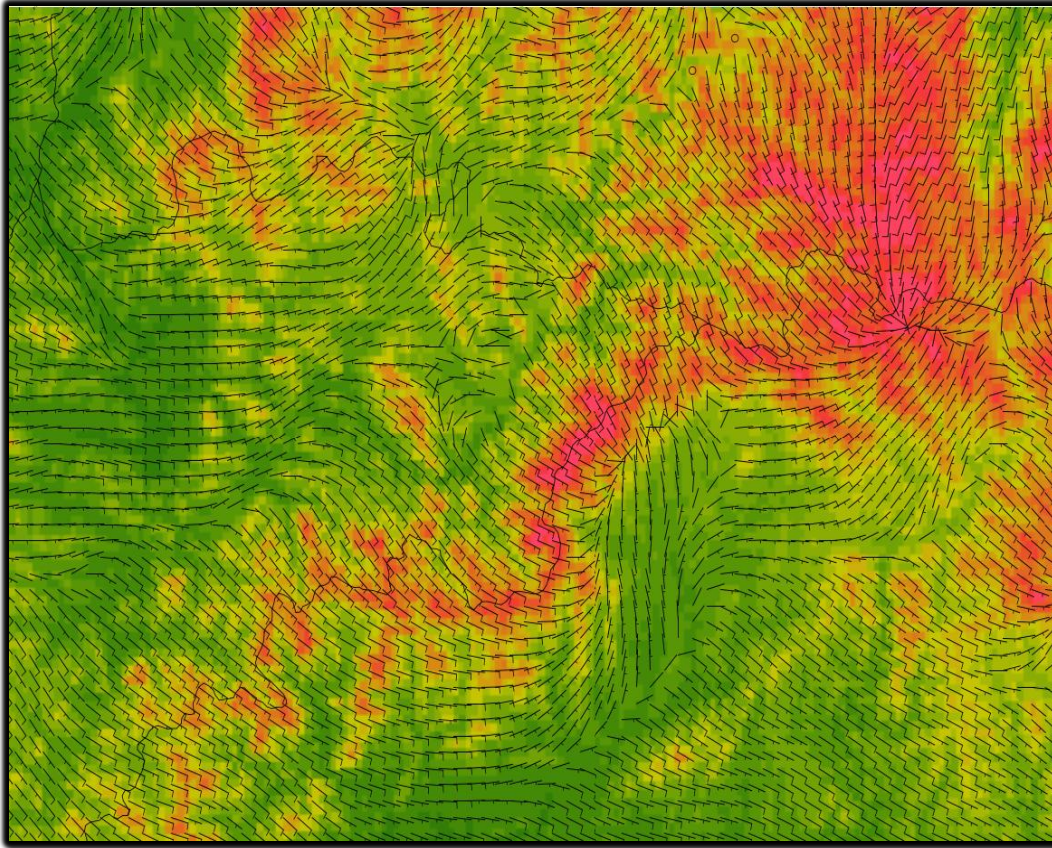
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Regional NWP

WRF



1.67 km WRF Window over Korea
(Surface Winds with Colorized Terrain)



Model Run Time: 2012-03-14T06:00:00Z

Weather Research and Forecast (WRF) model

- Development agent is NCAR
 - Run at 15 km with 5 & 1.67 km nested resolution windows
- WRF DA system
 - Currently 3DVar (WRFVAR)
 - Transition to GSI is being worked - ops cutover planned in 2012
 - Hybrid GSI soon after



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Ensemble Modeling

Global & Mesoscale Capability



Welcome To AFWEPS
AFW Ensemble Prediction Suite (prototype)

DOCUMENTS | TRAINING AND EDUCATION | MEETINGS | GLOBAL | MESOSCALE

ENSEMBLES AHEAD

JEFS

Send Us Your Feedback

- **Global Ensemble 2x/day**
 - NUOPC multi-model inputs (GFS, GEM, NOGAPS) forecasts to 240 hours
- **WRF-based Global & Regional Ensembles 2x/day**
 - Global to 144 hours
 - 12 km Nests to 48 hours
 - 4 km Nests to 24 hours
 - 10 members using varying physics and lower boundary conditions
- **Training & Outreach**
 - Working with forecasters & decision makers
 - Formal training via CBT and COMET

Probability Products:

QPF Thresholds, Precip Type, Snowfall, Cloud Cover, Lightning, Hail Size, Dust Lofting Potential, Severe TRW, Blizzard, Wind Gusts, Ceiling/Visibility, Wind Chill, Heat Index, Haboob Threat



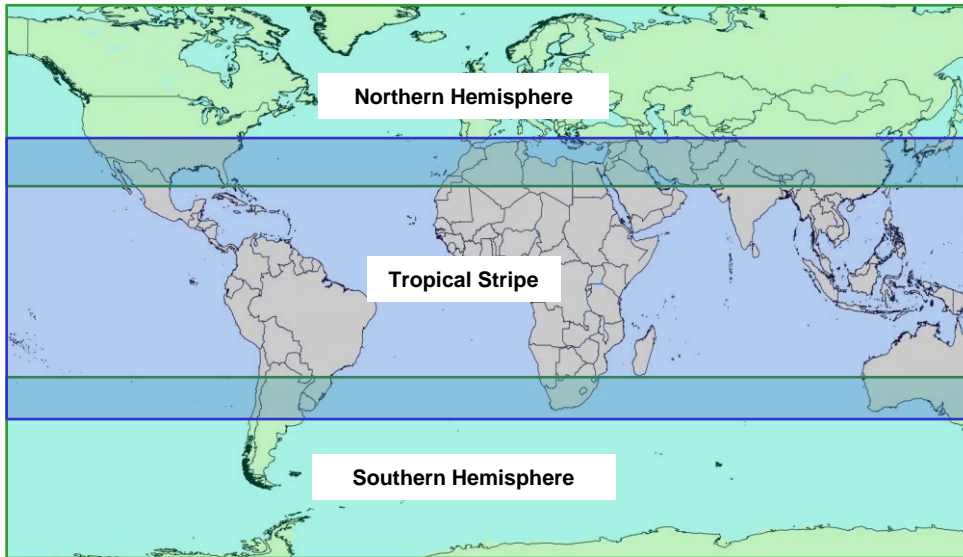
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WRF Ensembles

Global & Regional



Global 40 km WRF Ensembles



12 km WRF Ensemble Regions



4 km SWA WRF Ensemble



50 knot wind gust probability at 19Z
58 knots observed at 1911Z
Black contour = where individual ensemble member forecasted 40 knots sustained

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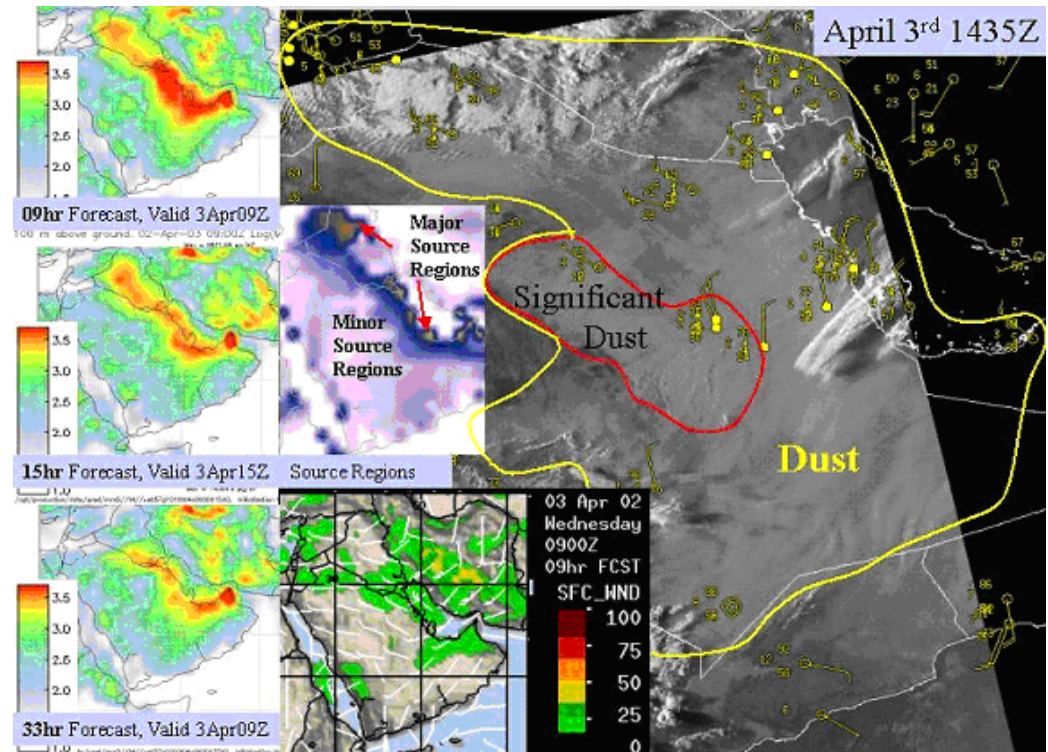
Aerosol Modeling

Dust Transport Application & WRF-Chem



■ DTA (GFS & WRF based)

- GFS DTA 1/2 degree resolution, 4 cycles/day out to 72 hours, 2 cycles/day out to 180 hours
- WRF DTA 15 km resolution, 4 cycles/day out to 48 hours
- Dust concentration and Dust visibility products
- Both use Ginoux source regions
- Near future: DRI development of hi-res source regions



■ WRF-Chem

- AFWA is developing WRF-Chem based aerosol forecasts (including dust) with transition to Ops planned in CY2013
- WRF-Chem simulates the emission, turbulent mixing, transport, transformation, and fate of trace gases and aerosols. The WRF Atmospheric Chemistry Working Group is guiding the development of WRF-Chem.



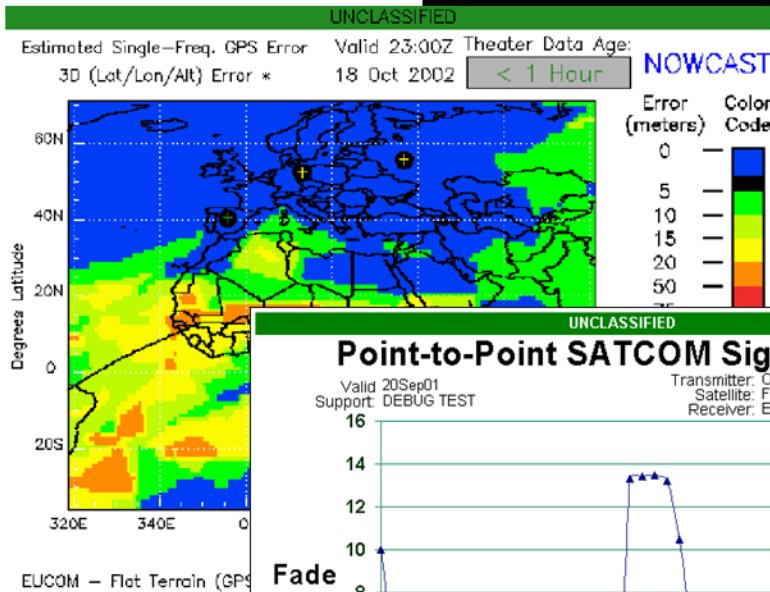
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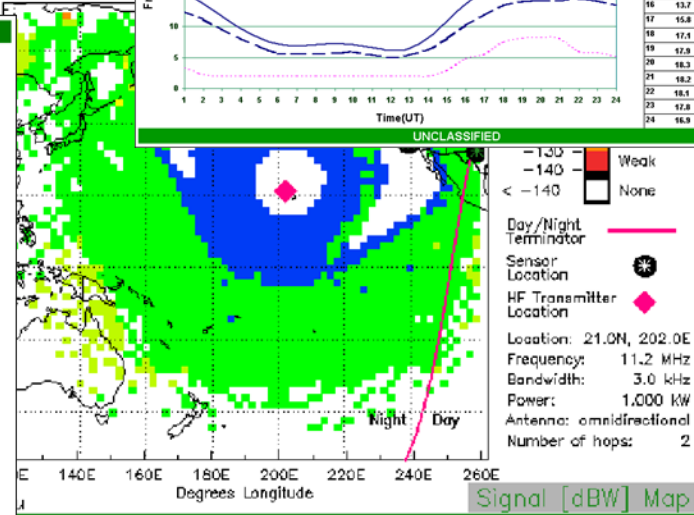
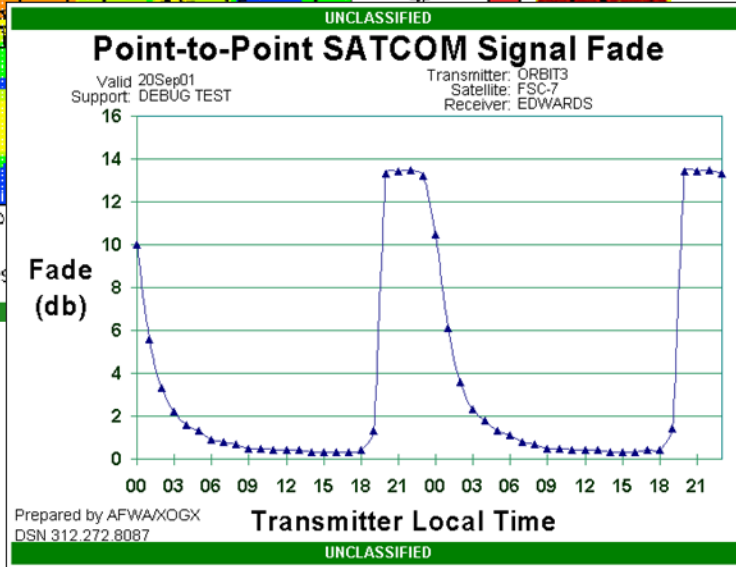
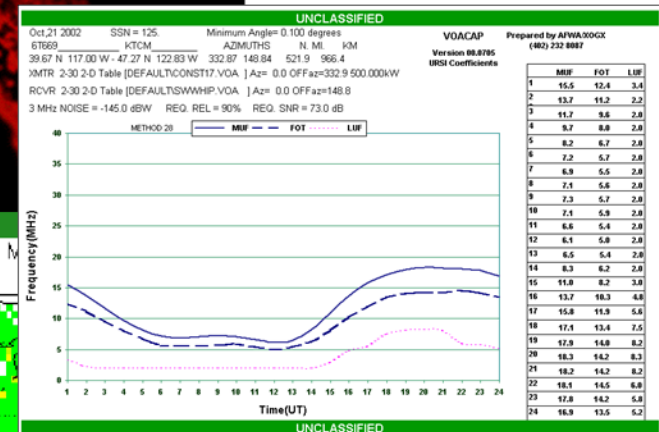
Space Weather Models

Multiple Models – Sun to High Stratosphere

Estimated GPS Error



Climatological Data



SATCOM Impacts

HF Illumination Maps



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Long Range Forecasting



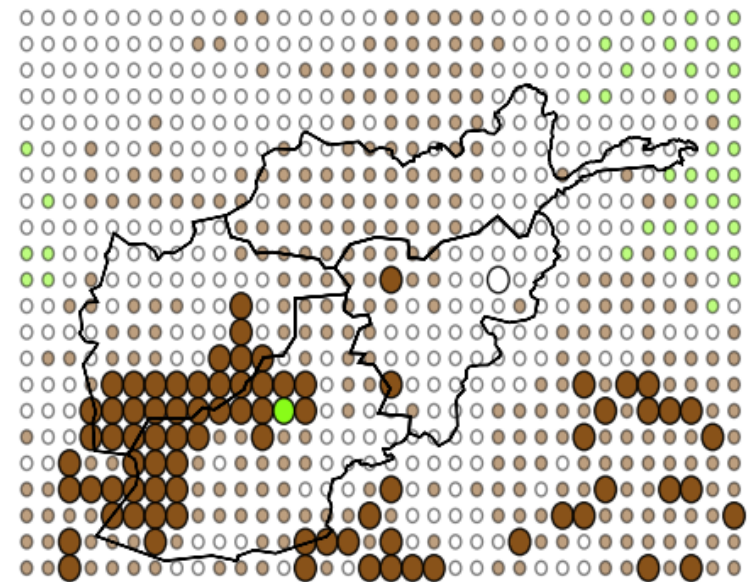
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Long Range Forecasting

Seasonal to Annual



- Initiatives at 14WS began in 2007 to investigate and research Long Range Forecasting (LRF) capabilities
- 14 WS coordinated with the Naval Postgraduate School (NPS) METOC department regarding LRF possibilities
 - 14WS leveraged NPS research to create composite Tercile Forecasts based on the Climate Prediction Center (CPC) El Niño Southern Oscillation (ENSO) index forecast
 - Narrative 6-month LRFs are built for 8 regions using the composite method, NPS forecast techniques, International Research Institute (IRI), and other LRF models
 - Evolving toward graphical Tercile Forecasts (below, normal, above) for temperature and precipitation with confidence levels





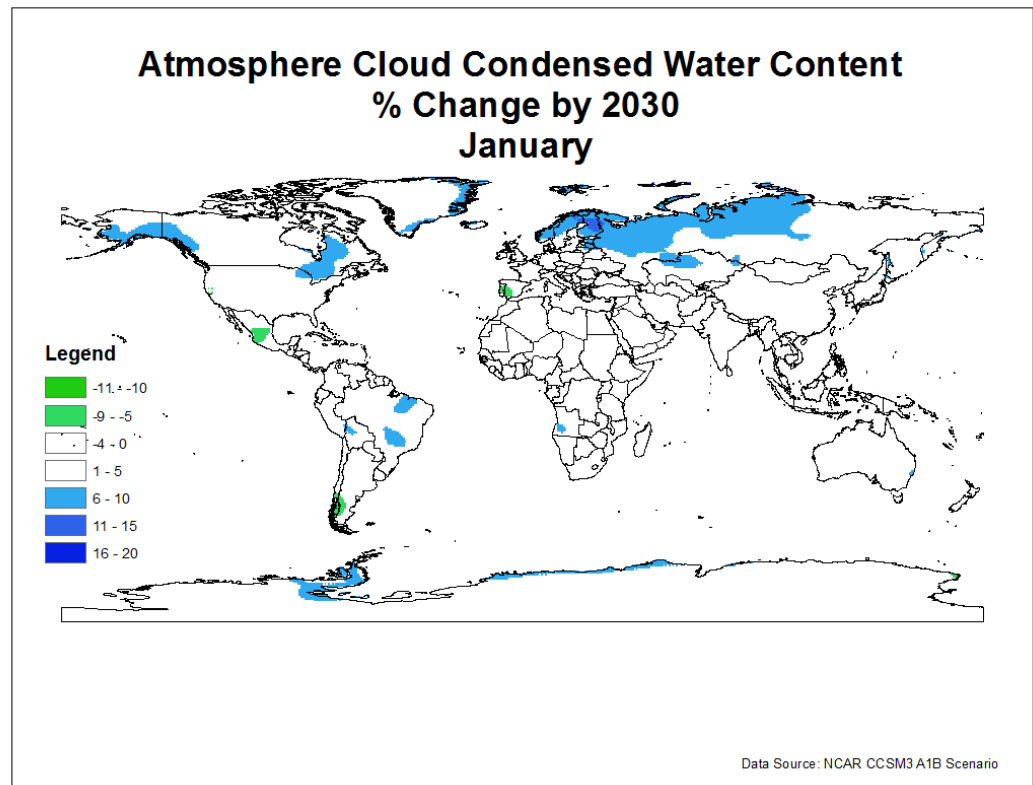
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Long Range Forecasting

DoD Climate Change Impact Analysis



- 14 WS has created 2030/2050 climate change text and graphic products at request of OSD using output from the NCAR Community Climate System Model (CCSM)
- Products developed
 - Temperature
 - Precipitation
 - Humidity
 - Extremes
 - Cloud Cover





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AFWA HPC Modeling System



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AFWA HPC System

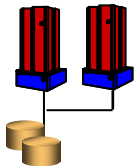
As of Mar 2012



UNCLASSIFIED

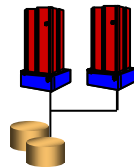
Prod8: Spec Models/Ensembles

1280 Cores
12.5 TFlops



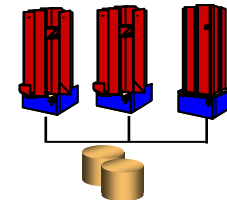
Dev8: Dev/Test

192 Cores
2.0 TFlops



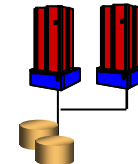
★ Prod9: UM/WRF/Ensembles

4800 Cores
51.0 TFlops



R&D

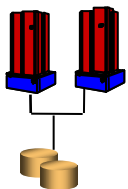
256 Cores
2.5 TFlops



CLASSIFIED

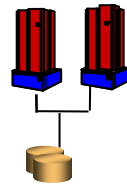
SProd8: Spec Models/WRF

576 Cores
9.0 TFlops



SProd9: WRF 1.67km

1344 Cores
14.0 TFlops



Computing Capacity:

Unclassified: 68 TFlops

Classified: 23 TFlops

Total: 91 TFlops

Power :

Available: 1,225 Kw

HPC Usage: 308 Kw

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Questions?



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